A Bayesian network approach to evaluating electrical ignition in fire investigation

by

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Certificate of Authorship and Originality

I certify that the work in this thesis has not previously been submitted for a degree nor has it been submitted as part of requirements for a degree except as fully acknowledged within the text.

I also certify that the thesis has been written by me. Any help that I received in my research work and the preparation of the thesis itself has been acknowledged. I certify that all information sources and literature are indicated in the thesis.

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August, 2005

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Abstract

Investigation of the cause and origin of a fire is a task hindered by several sources of uncertainty. Electrical ignition represents a particularly problematic type of fire to investigate, due chiefly to the fragility of the physical evidence and the difficulty distinguishing between electrical damage that has *caused* the fire and electrical damage caused *by* the fire. Current deviation is a type of electrical ignition that is relatively unknown, yet its ability to cause ignition without alerting protective systems makes it more dangerous than a common overcurrent. The lifetime of the process is highly variable, able to proceed without warning anywhere from days to years before ignition. Furthermore, the transient nature of current deviation means that it is especially difficult for investigators to find direct, tangible evidence that it has occurred. Steeped in such a high degree of uncertainty, current deviation was selected as the type of electrical ignition with which to examine a new approach to fire investigation based on Bayesian Belief Networks (BBN).

Bayesian networks are graphical structures that use mathematical probability to represent and analyse influential relationships between variables in a system. This scientifically rigorous method for dealing with uncertainty makes it an ideal aid for investigating current deviation. Further advantages to this approach include the immediate propagation of evidence and the ability of the graphical network to visualise complicated phenomena in an economical and intuitive manner.

A Bayesian network was constructed to represent current deviation, based on the three types of evidence required for ignition. For each type of evidence a fire investigator must express an expert opinion in the form of a numerical probability. Bayesian inference is then used to calculate the likelihood of the hypothesis that conditions existed for current deviation to occur.

Two types of analysis were performed with the Bayesian network for current deviation. A single-value approach using Hugin Lite® software provided a fast and simple method for computing the probability of the hypothesis as a solitary number. The Matlab® software package was then used for an advanced distribution-based analysis that allowed quantification of uncertainty throughout the investigation. Sensitivity analyses were also implemented to enable the expert to calculate the contribution of each type of evidence and guide the investigation accordingly.

Bayesian networks proved to be an effective decision aid for dealing with uncertainty in the investigation of ignition by current deviation. Recommendations and guidelines for use of this technique were formulated.